COMELY GREEN PLACE

SUSTAINABLE HOUSING PROJECT

SUSTAINABLE DESIGN SPECIFICATION

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Contents

1. INTRODUCTION

This confirmation report is submitted along with the enclosed Sustainable Materials Specification as evidence of having achieved Milestone 2 of the Comely Green Place Sustainable Housing Project (Contract Reference 39/3/484 cc1737). The report aims to give a summary of the processes of assessment and consideration that went into the final decisions, as well as to give some indication of some ideas which have been considered and rejected, with reasons for these decisions.

2. DECISION MAKING PROCESS

In addition to research undertaken independently by Wren & Bell, the Project has been managed largely through the forum of the design team meetings, which have routinely been attended by the following parties:

- Link Housing Association
- Hart Builders
- Wren & Bell Structural, Civil and Environmental Consultants
- Norman Gray & Partners, Architects
- Pottie Wilson Partnership, Quantity Surveyors

This forum has encouraged the active participation of all members of the design team in discussions regarding material choice. This participation has proved essential for the correct specification of many materials. For example, a cheap material that has excellent environmental performance may be inappropriate for operational reasons that might not occur to an environmental scientist and conversely, materials that are routinely used in construction may have environmental issues that would not have occurred to other members of the design team. In these situations the forum has proved essential but it has also been useful in situations where there is a delicate trade-off between the three criteria, as in these situations it is vital for all points of view to be aired, so that the best overall option can be chosen.

The discussions have been largely based on background research and life cycle assessment undertaken by Wren & Bell to provide an unbiased comparison of environmental impacts of materials during raw material extraction, manufacture, use and re-cycling or disposal. In essence, this choice has depended on the performance of rival materials in environmental, operational and financial terms. The main principle of the project has always been to minimise the environmental impact of the development over its design life. Secondary to this principle is that the decision-making process should be easily understandable, to remove as far as possible the barriers that might prevent a non-technical team from building another more sustainable development. Observing these principles requires a sensible trade-off of sometimes contradictory considerations for each material, while at the same time ensuring that the reasons for each decision are clearly stated.

An early decision in the project was to extend the design life of the building from the usual 60 years to 100 years. There are arguments for and against this decision, which will be discussed at greater length elsewhere. However, for the purposes of this document, the decision had a profound knock-on effect on the selection of materials, since some inaccessible items like roofing had to have an extended working life, as replacing them would be impractical.

We do not expect everyone to agree with our interpretation of the available information but we do aim to show all the assumptions and decisions we have made, so that disagreement need not proceed from a position of ignorance. We hope that this approach will help to advance the practice of sustainable building and welcome discussion from any interested party.

3. SITE PREPARATION AND FOUNDATIONS

The Comely Green Place site is a contaminated “brown field” site. The issues associated with this situation have been addressed and present no significant risk to the development. Since the site is fixed, this is not strictly an issue of choice for the programme but it is included in the specification and will be further discussed in the web site and manual for the benefit of future developers.

3.1 Site Preparation

We feel that the use of contaminated land is a pre-requisite for sustainable construction. The extent of remediation required for contaminated land depends on the proposed end use. In effect, this means that severely contaminated sites can only be economically remediated for use as industrial sites or flatted developments such as Comely Green Place. Other uses, such as houses with gardens, parks or agriculture present far greater potential for pathways between contaminated material and site users. Since practically any use of a green field site will end up contaminating it to some extent, it is therefore evident that a sustainable housing policy cannot use such sites, as doing so will lead to a slow but inexorable degradation of land quality; in effect, a consumption of uncontaminated land.

In this case, relatively minor remediation measures were required to enable the development to proceed. In our experience, the remediation of contaminated land rarely creates a significant barrier to development. The cost of remediation can usually be estimated quite reliably and this estimate can then be used in negotiating the price of the site or in calculating the economic viability of the development. If further assurance is required then insurance products are available which effectively transfer any risk away from the developer.

3.2 Foundations

Foundation design was the first and one of the most difficult areas in which to reach an agreement between the environmental and structural considerations of the project. Concrete has a very high embodied energy, which is related to its cement content (cement manufacture is one of the most energy-intensive industries). However, the structural properties of the concrete are also related to its cement content and to the proportion of recycled material used in its manufacture.

This situation was the subject of much discussion: from an environmental point of view, we wanted as little concrete as possible, with as high a recycled material and ground, granulated blast-furnace slag (GGBS) content as possible. From an engineering point of view, particularly in the light of the extended design life, no compromise was acceptable if it affected the long-term stability of the structure in any way. A further consideration was the effect that the site contamination might have on the design of foundation materials and the materials themselves.

Eventually, piled foundations and ground beams constructed from a high-GGBS content concrete (but without recycled aggregate) were chosen, overlaid with a suspended timber ground floor, which would be constructed from local sustainably-produced timber, treated with boron. The composition of the concrete is based on the best available compromise between the environmental impacts of manufacturing the material and the long-term structural requirements. Thus, although the use of recycled aggregate was abandoned because of its potential detrimental effect on structural performance, recycled GGBS cement was specified to minimise the requirement for Portland cement.

GGBS has a slightly longer curing time than traditional cement, which must be taken into account when programming the building works but once cured, it is actually superior to Portland cement in its structural properties.

High GGBS content concrete is also far more resistant to attack from corrosive materials in contaminated land, such as sulphate and chloride. This resistance is required anyway for laying foundations at the site, so the sustainable specification actually fulfils one of the important requirements for the remediation of brown field land.

4. BUILDING STRUCTURE

The initial discussion as to which building technique to use for the development was relatively short-lived. The environmental and operational performance of timber frame manufacture is far better than comparable methods such as steel frame or load-bearing masonry and in this situation there is no reason not to use this construction method. However, this is a major decision in any development, particularly where sustainability is an issue, and further clarification of the assumptions and logic behind it will be included in the final report.

4.1 Timber Frame Structure

Once decision had been made to use timber frame construction, the next step was to optimise the environmental performance of the timber frame construction method. The first hurdle to overcome was obtaining local, certified sustainably produced timber of sufficient quality. Timber frame manufacturers have traditionally imported their raw materials from Scandinavia. Since the quality is consistent and the price is comparable to that of Scottish timber, there has been no pressure on them to change this practice, until now. Wren & Bell undertake a significant proportion of timber frame engineering design, so we were able to use our contacts with the suppliers to explore the possibility of using locally produced timber.

Once this had been accepted as workable in principle, we set about the task of tracking down a supplier that could provide timber:

- to an acceptable, certified engineering grade
- from certified sustainable forests
- from local forests
- largely untreated
- where treatment was necessary, treated with boron.

Such a supplier was eventually located in the form of BSW, based in Fort William. They are the only timber supplier we have found that are able to fulfil all the above criteria.

Once these difficulties had been overcome, we had to consider what modifications would be required to the timber frame design to optimise lifetime environmental performance. Various issues were considered which will be discussed at greater length, such as vapour barriers, breathing wall construction, air-tightness and the requirement for treatment. However, in overall sustainability terms, the major issue was the trade-off between the cost of the timber kit and the thickness of insulation that it could accommodate.

Bearing in mind the fundamental principles of the project, this trade-off was resolved by increasing the 89mm stud thickness of the standard specification to 140mm, allowing almost 60% more insulation to be placed within the timber frame. 140mm is still a standard stud size, which helps to keep the price down but it is unnecessarily thick for purely structural purposes. This means that a certain amount of re-design will be required to optimise the structural performance of the timber frame but it was felt that this option represented the best compromise, both in terms of overall lifetime environmental performance for price and in terms of the ease with which it could be adopted by future developers.

4.2 External Wall Design

Given the extended design life of the development, it was decided that a traditional rendered block finish would be required to give adequate protection against the elements. Alternative materials are available which have an even smaller environmental impact but they all require extensive regular maintenance and do not provide the operational performance required for the Scottish climate. The environmental impact of manufacturing high recycled content blocks, particularly locally, are relatively minor, particularly considering the established benefits of using this materials in the external wall construction.

A number of local suppliers have been identified that supply high recycled content blocks; the best having a recycled content of 90%. However, not all blocks are produced to the same consistent quality; in the end, a reputable supplier was located that manufactured 85% recycled content blocks that have been used by Hart builders in previous developments and which are known to perform well. This kind of practical product knowledge is invaluable for the successful adoption of sustainable housing practice. No-one is going to follow the example set by Comely Green Place if the building leaks and the blockwork crumbles in the first few years!

Discussions regarding the specification of external wall sheeting resulted in the choice of oriented strand board manufactured to comply with BS EN 300 and certified to have a total extractable formaldehyde content of less than 0.005%. This specification aims to achieve the structural requirements of the material while minimising both resource depletion and off-gassing of formaldehyde, which has been implicated in sick building syndrome.

An additional specification was that the render should be produced in batches off-site. This leads to a higher quality and consistency of finish and reduces waste material on site, as there are no piles of sand and broken bags of cement lying around. Also, details and sills will be made from processed stone or concrete; each has less impact on the environment than natural stone but the difference between them is considered to be slight.

4.3 Roof Covering

A suitable roofing material with good environmental performance was perhaps the most difficult material to find. The required performance and longevity of the this part of the building structure meant that no compromise was acceptable from the builder’s point of view. It was no good using the most environmentally friendly material if we then had to put scaffolding up every ten years to replace it.

With this in mind, we had to find a material that was known to do the job well but which had an acceptable environmental impact during manufacture. Consideration was therefore given to aluminium sheeting, slate, concrete, processed slate and even lead. In the end, the best balance of performance, price and durability was found in processed slate. This is made with 85% slate waste, the remainder being made up with epoxy resin. A typical slate mine works at about 5% efficiency, so this is a genuine use of what would otherwise be a waste material. The background to this decision will be given in greater depth, particularly in the light of the increasing availability of potential alternatives such as specified 100% secondary aluminium sheet, which may be a preferred option but was not available at the time of specification.

5. ENERGY USE AND CONSERVATION

The main structural elements of the development have the greatest immediate environmental impact in terms of their embodied energy and the resource depletion and pollution associated with their manufacture. However, over the lifetime of the building, energy use and conservation will have a far greater impact. This section covers the decisions leading up to the final specification for energy systems and insulation.

5.1 Heating

Over its design life, energy consumption during use is arguably the greatest environmental impact from any construction project. It is therefore essential to any sustainable construction project not only to minimise energy use but also to minimise the environmental impacts of energy generation.

There is a variety of impacts from energy generation which depends on the form of generation used. The principal impact of most generation types is the contribution of carbon dioxide to global warming but there are also considerations such as SO_2, NO_x, particulates and radioactive contamination to be considered, both on a local and global scale.

One particular problem, which has been exacerbated by recent developments in the energy market, is that it is no longer legally possible to specify the most sustainable form of energy supply. The domestic energy system with the lowest environmental impact is electricity generated from renewable sources, such as biomass, windpower, hydroelectric etc. This is, by definition, the only sustainable energy source currently available. However, since electricity deregulation, it has not been possible to specify the source of electricity, since consumers must be allowed a choice of supplier. Since renewable electricity is typically slightly more expensive than electricity from other sources, and because money usually takes precedent over environmental considerations, specifying any form of electricity effectively means specifying the cheapest (and often the dirtiest) form of electricity.

We are therefore left with the next best option, which is to minimise the quantity of CO_2 and other environmental impacts that result from the generation of energy for the development. Since electricity is effectively ruled out for the reasons given above, this leaves generation on site as the best remaining available option. In practical terms, the project was therefore left with a choice between a combined heat and power (CHP) system or various designs of conventional heating boiler, with grid electricity for appliances and lighting.

CHP was initially considered the best option, since the CO_2 output per unit of energy generated is less than that for other methods. Other benefits included the possibility of the housing association being able to provide heat and power with rent, which would allow them to maintain the quality of internal environment. A common problem with public sector housing is that occupants are reluctant to maintain a comfortable level of heating because of the expense. Link reasoned that if they could take on the burden of operating a CHP plant for the site, they could provide an integrated package of heat and power within the rent, which would allow occupants to enjoy a better standard of living.

The heating control system required within each flat when a CHP system is in use is relatively simple and robust, which was also considered a benefit.

However, calculations of the peak load and demand pattern for electricity and heating showed up two main points:

- a CHP plant typically generates about twice as much heat as power, which in this situation would mean that generating sufficient electricity would also generate considerably more heat than is required.

- the demand of the building would mean that electricity from the plant would cost the same or slightly more than electricity supplied from the grid, making the economic argument tenuous.

Also, since the site is relatively small and the development is quite crowded, the location of the plant required careful consideration. A CHP generator is effectively a diesel engine coupled to a dynamo; this means that the building housing the engine has to be sound-proofed and a sufficiently high chimney is required to carry the exhaust above the level of the flats. Even with these modifications, the engine would be audible when in operation.

Despite the negative aspects and difficulties that come with a CHP plant, the design team would still have been committed to the idea were it not for one remaining difficulty. As mentioned at the beginning of this section, it is not legal to insist that someone accept electricity from any particular supplier; they must have the right to choose. It was therefore not possible to guarantee that the predicted electricity demand from the development would materialise. Since this level of demand was in any case marginal for making an economic case for the plant, a decision was made to halt development of the CHP option.

One further point is worth mentioning here: throughout the course of our investigations into CHP, we contacted a number of interested organisations, such as Cogen, the CHPA and electricity supply companies. All of these naturally make a great play about how efficient CHP systems are, how environmentally friendly and how they are suitable for remarkably small developments, even single units. However, when it comes down to hard facts, advice and even assistance, their enthusiasm quickly evaporates, leaving the developer alone with a simple financial decision and little practical encouragement or help.

At the moment and for this development, CHP is not the answer. However, technology moves on and every development site is different. We hope that future developers will not be discouraged by our experiences and that they will make the effort to use CHP wherever it is practical to do so. We are particularly enthusiastic about the potential for fuel-cell CHP, which will increase the efficiency of generation still further, even up the balance between the amount of heat and power produced and improve the quality of emissions. However, this technology is still a few years away, with the first examples world-wide only being installed this year.

The decision to abandon CHP for this development then left the options of individual or communal boilers, as well as the choice of boiler design. A plan was developed for a communal hot water system, which would lead to increased efficiency in the generation of heat, as well as improved control of internal conditions, particularly in the housing association flats. This plan met with two main problems. Firstly, it was difficult to establish whether the scheme could be extended into the private sale flats and if it were, how the sale of the heating system would be arranged. Secondly, the standard specification already included provision for gas cookers in all flats, so a gas supply would in any case be available. These two points made the economic argument for a communal system too poor to balance against a relatively modest environmental improvement.

This chain of decisions left us with the option to select various types of individual gas boilers. The most efficient type currently available is a balanced-flue condensing gas boiler, so this type was specified for each flat in the development.

5.2 Electrical Goods

Most household electrical appliances are now rated under the EC Energy Efficiency Rating Scheme. This gives a rating between A (best) and F (worst). The rating does not, however give any information regarding the energetic and environmental costs of manufacturing the appliance.

A brief survey of available appliances shows that companies which have gone to the effort of developing energy efficient appliances have usually done so as part of an overall commitment to improved environmental performance. The likes of Bosch, AEG, Siemens and Philips all have energy efficient models and all have certified environmental management systems.

Also, over the lifetime of these products, operational energy efficiency is likely to have a greater impact than the initial efficiency of production. This, coupled with the increasing prevalence of take-back schemes for these appliance, encouraged the design team to regard the established energy efficiency rating as a good guide to the overall environmental performance of the products.

Whilst investigating the cost and efficiency of these appliances, we also took a view on the best rating in terms of environmental value for money. A-rated machines seem to command a price premium simply because they have the best rating; we therefore selected the B-rating band as best meeting the principles of the project in terms of a balance between financial, operational and environmental considerations.

5.3 Insulation

Improved insulation is one of the key areas where improvements can be made in the performance of housing, both in environmental and financial terms. The current artificially low level of fuel prices makes it difficult to present a good economic argument for specifying the amount of insulation that is required from an environmental perspective. However, over the lifetime of this development, fuel prices are unlikely to go down. Whether through resource depletion, a carbon tax, a greater appreciation of the effects of global warming or for reasons that we cannot foresee, it is likely that the currently externalised costs of energy production will be internalised at some point.

There are therefore a number of reasons why improved insulation is a vital aspect of any sustainable housing project. However, some of the materials used as insulation have significant environmental impacts in their manufacture. Blown foam materials, for example contain harmful gases and volatile organics; glass-based materials have high embodied energy. Against these considerations must be weighed the performance of the material in use. The environmental impacts of an insulating material's manufacture will typically be easily outweighed by the saving in energy and carbon dioxide generation it can bring over its useful life.

We were therefore careful first to select the best materials for the job that were available at a reasonable cost, then to choose the best of these in terms of manufacturing impacts. The result of this process was specification of blown cellulose insulation. This has the same insulating properties as the glass fibre material that is normally used, with the added advantage that it has a much lower impact during manufacture. A further advantage of using this material is that it is blown into the timber frame after it has been erected; this helps to fill air gaps that can be left when solid insulation materials such as glass fibre are used. Minimising these gaps leads to a far better overall performance of the building envelope.

This insulation material will be used throughout the building, including the roof space and underfloor insulation on the ground floor.

5.4 Windows and Glazing

The window frames for the building will be subject to the same selection criteria as other timber materials although, unfortunately we could not locate a manufacturer that uses Scottish-based timber. Apart from this aspect though, the frames will be boron treated and come from certified, sustainably managed forests. uPVC and aluminium frames were also considered but the performance of timber framed windows is so good now that there is practically no performance loss in specifying this type, while the environmental impacts of manufacture are considerably reduced.

The window glass itself is, again a compromise between performance and price. It is possible to get a slightly lower U-value from triple glazed units for example but the specification of argon-filled, low-emissivity double-glazed units represents the best value for money in terms of window insulation.

5.5 Ventilation

The combination of high insulation levels, high performance windows and draft proofing detailing in the final design means that heat loss through ventilation becomes a significant factor. In effect, there is so little heat loss through the walls and windows that most heat is lost through ventilation. The design team looked at a number of systems to reduce this loss of energy. These all include a heat exchanger to transfer energy from stale air leaving the building to fresh air coming in. The difference between the designs concerns the systems used to collect and move the air.

The initial selection was for a “Passivent” system, which uses external air movements to draw air out from the building. This system has no moving parts and requires no power, so it had obvious attractions from environmental, operational and financial points of view. However, calculations showed that the system would not provide an adequate air change rate for the development, particularly in ground floor flats. This is particularly important in this development because, if the occupants find the flats too stuffy, they will open the windows, which negates the purpose of the design entirely.

Given that a powered system was required, consideration was then given to a number of collective systems, which would allow bigger and more efficient fan units to be installed, as well as more efficient heat exchangers. The plan was to draw air out through collecting ducts to a central fan unit in the roof void, which would serve up to eight flats. Fresh air would be drawn in through the heat exchanger and pumped into the stairwell, from where it would return to the flats. In terms of energy efficiency, this system appeared to be a good option. However, there were two main difficulties with it. Firstly, the return air vents from the stairwell would present a fire hazard, so a full return air ducting system would also be required. Secondly, the use of a combined venting system would create the potential for kitchen and bathroom smells to move from one flat to another.

At this point, we decided that the cost/benefit principles of the development would be better observed using a simpler system. We located a standalone heat exchanging extract fan system that can recover 60% of the energy that would be lost in ventilation exhaust. This system can be linked to light switches in the kitchen and bathroom of each flat and will require minimal additional installation. In some cases, the layout of the flats requires a small additional duct to carry exhaust and return air but this is insignificant compared to the elaborate requirements of other proposed systems. Each unit draws about 12W of power and saves about 140W of heat energy, so the overall benefit is clear.

6. ADDITIONAL ITEMS

In addition to the main building structure and energy systems, there are a number of other items in the development that require particular attention. The reasons for this are varied: some items have the potential to generate noxious gases, which are implicated in sick building syndrome. Others use materials whose manufacture and use is contentious, such as PVC. Still others have further environmental issues associated with them, such as re-use and recycling, resource depletion and embodied energy. These items are covered below.

6.1 Sick Building Syndrome

A clutch of symptoms including low productivity, headaches and general malaise have been grouped together and described as sick building syndrome. The causes of this syndrome are not well understood but they are thought to include the amount of daylight people get in a building, the number of air changes per hour, the quality of the internal atmosphere and other factors. The ventilation of this development will be controlled by individual occupants, so there should be no reason for the flats to be stuffy. Also, the heat exchanging ventilation system will provide fresh air with minimal energy loss, so it should not be necessary to open the windows just for fresh air. Daylight exposure is constrained by the requirements of the development, although the design does attempt to make the flats as bright as possible within these constraints. The following items have been particularly discussed in the light of their potential to affect the internal atmosphere of the development.

Internal timber-based materials

The traditional materials used for the internal lining of the timber frame are plasterboard and chipboard. Our research showed that there was a broad range of environmental performance in the manufacture of these materials. We did not find any alternative materials with a better environmental performance than the best of these traditional materials, so the final specification is for 100% recycled flue gas gypsum plasterboard and chipboard manufactured to the BS EN 312, which ensures that the off-gassing of formaldehyde is minimised.

The specification of the external and stairway doors observes the same criteria as the timber frame in terms of sustainable production and best practice manufacture. Internal doors can be specified with still lower environmental impact by using a honeycombed paper construction with hardboard skins.

There was much discussion regarding the joinerwork, such as skirting boards. Essentially, the argument came down to a choice between natural wood and medium-density fibreboard (MDF). Each has good and bad points: natural wood can be sustainably produced whereas MDF includes phenolic resins that are produced by the petrochemical industry. Pre-formed natural wood makes use of less than 50% of the original tree, whereas MDF makes use of over 80%. Also, MDF is easier to work, of more consistent quality and requires less paint to achieve the required finish.

MDF does contain trace quantities of formaldhyde but these are some orders of magnitude less than those found in chipboard and well below the levels required by the British Standard regulations. The final specification decided in favour of MDF as it was felt that the advantages of using it outweighed the small disadvantages. A final point that tipped the balance in favour of this material was that it is the standard material already, so that the builders are used to working with it, which should lead to the generation of less waste.

For economic reasons, kitchen fittings will most likely be made from chipboard and fibreboard. This material will be certified to have a formaldehyde content in accordance with the current European regulation BS EN 312.

Paintwork

Many paint formulations can contain high concentrations of biocides, emulsifiers and solvents which are hazardous to the environment and to human health. These substances can have environmental impacts during manufacture of the paints, during application and in disposal of partially empty containers.

The solvent content of paints can cause harmful effects to workers in the long term and is also implicated as a contributory cause of sick building syndrome.

External paints are required to stand up to more harsh conditions and are also less likely to contribute to degradation of the internal atmosphere. However, solvent emissions from these paints will contribute equally to the external effects of these substances, such as photochemical smog and low level ozone generation, which in turn lead to increases in the number of respiratory ailments.

The specification for paints to be used in the development has to balance these environmental considerations against the performance of each product. After all, there is little point in specifying an environmentally benign paint which then fails to protect the material it is coating, leading to a requirement for the replacement of that material.

The final specification stipulates water-based paints for internal applications, to cut down the emissions to the external atmosphere as far as possible. External paintwork requiring a more durable finish will use high-solids alkyd paints.

6.2 Polyvinyl chloride (PVC)

One of the main issues encountered during this research programme concerns the use of PVC. There appear to be two entrenched camps with religiously held views and precious little middle ground. These views are represented by The PVC Retail Working Group on one hand and Greenpeace on the other. Greenpeace has singled out PVC as representative of the worst environmental aspects of the chemical industry as a whole. They are forced to do this, as their campaigns must be straightforward and easily understood if they are to be successful. However, this approach also has the effect of oversimplifying the issues and encouraging hysterical overstatement to emphasise their point of view.

Defending the production of PVC, the Retail Working Group has tried to use a more rational approach. Many of their members have environmental management systems in place to control and reduce their toxic emissions and the data collected by these systems have been used in an attempt to form a counter-argument to the Greenpeace campaign. This is not to say that the industry is blameless; there have certainly been significant acute and chronic pollution incidents associated with PVC production in the past and there may be issues associated with its performance in accidental fires. Although the industry appears to have done its best to answer the campaign in a level, rational way, it cannot be impartial in this matter and its reports cannot therefore be entirely trusted

The main Greenpeace report for this campaign, "Building for the Future", contains a suppliers guide that suggests some alternatives to PVC. For this project we have used this guide, along with others like it, and assessed the suitability of PVC and its alternatives in terms of the principles of the project. We have tried to make use of all available information and to form an unbiased view; however, the battle lines have been drawn and any decision made here will undoubtedly be vilified by those that oppose it and applauded by those that support it. This decision-making process has been undertaken for each situation where PVC would normally be used, as its use is more acceptable in some places than others. For example, soffit boards must be effectively maintenance-free, as gaining access for maintenance is extremely problematic. Another example would be the internal drainage system: a reasonable alternative to PVC in this location would be high-density polyethylene (HDPE), except that this material must be thermally welded rather than screw-fitted, which presents difficulties when it comes to recycling the material at the end of its life.

This issue will form a major part of the report, not because it is of particular relevance in terms of the principal aims of the project but because it is a high-profile topic, which must be clearly explained so that any argument which ensues can at least be based on clear reasoning.

The following items either include PVC or are replacements for PVC products.

Plumbing

The selection of material to be used for plumbing amounted to a consideration of alternatives to PVC. As in the case of electrical fittings and cables, outlined above, PVC is the standard material used for this function. It is considerably cheaper than any alternative material and its operational performance is understood.

However, because of the environmental issues surrounding the manufacture of PVC, consideration was also given to polypropylene, ceramic and various metal systems. The main problem with polypropylene in this application is that is must be connected by thermal welding, rather than the conventional screw-fittings used for PVC pipes. This could lead to difficulties during dismantling, re-use and recycling; also, a complete HDPE system came to around three times as much as the equivalent in PVC.

Metal systems were considered but the environmental impact of these materials is too high, compared to plastic systems. Ceramic pipes were considered to be a good option from an environmental point of view but they were ruled out on the basis of cost and operational problems, as they more prone to damage than plastic pipes.

Electrical wiring

Alternatives to PVC are available in this application but their cost is currently prohibitive. Since one of the main principles of the development is that it should not cost significantly more than a standard development, the design team took a decision that this was not an area where this level of additional investment was warranted, particularly as the argument against PVC is not absolutely clear.

However, this is one area which will require to be re-visited with each subsequent sustainable development, since the PVC question and the relative price and quality of alternative materials change on an almost daily basis.

External valleys, soffits, gutters etc.

These items must be up to the job as the costs involved in repairing or maintaining them are prohibitive (e.g. scaffolding is required to work on soffit boards). These items are usually made from PVC, since it is waterproof and stable under exposure to sunlight. In this case, the design of the timber frame and roof details mean that the size of these items will be minimised. In some cases a suitable alternative material to PVC is available at a competitive price. Where this is the case, the alternative has been specified as a precaution. Roof valleys, for example will be made from glass reinforced plastic (GRP).

In the case of gutters, drainpipes and soffit boards, HDPE was the best available alternative. However, the extra cost was too great in this case. HDPE has a comparable problem to PVC as a structural material: its manufacturing process is unquestionably cleaner but there is a question regarding its stability in sunlight. As with PVC, good unbiased information on this topic is hard to come by. HDPE producers say that there is no such problem, others say there is. Given the additional cost and this potential problem, the design team decided to use PVC in this application.

6.3 Other considerations

Stairs

The fire safety regulations state that the stair cannot be constructed from flammable materials such as wood. The next best option was to make the stair cores out of concrete and to minimise the environmental impact by ensuring that the maximum proportion of recycled material is used in the mixture. The stair cores are not subject to the same quality control conditions as the foundations, which means that a higher recycled content concrete can be used. The same high recycled content blocks that have been specified for the external walls will also be used in the stairwells.

Banisters

Similar restrictions in the regulations mean that the banisters must also be non-flammable. This effectively meant a choice between steel and aluminium. Weight for weight, steel has a considerably lower environmental impact during manufacture than aluminium; however, it is also necessary to take into account the finished weight of the banisters. In this case, the design requirements of the banisters are such that they can be made from relatively light gauge steel, so this forms the final specification.

Plasterboard

Hart Builders main supplier of plasterboard is British Gypsum. We contacted this supplier regarding their environmental performance and they returned to us their environmental report, which contains a complete account of the environmental performance of the material during manufacture. BG's flue gas gypsum plasterboard has excellent environmental performance, being manufactured almost entirely from recycled materials. We therefore felt that specification of this material for the programme was appropriate.

6.4 *Finished Development Details*

Greywater

Water conservation has not been given as high a profile in Scotland as it has in drier climes, as the rainfall is that much higher, particularly in the west. However, this observation does not take account of the increased supply and sewerage infrastructure that is inevitably required for new housing developments. To fulfil the objectives of this project, the design team had to find a compromise between the requirement for water conservation and making the design easily repeatable.

For this reason, an early decision was reached that greywater recycling, with its associated infrastructure and hygiene problems, did not represent a good balance of costs and benefits. The added design, construction, operation and maintenance costs of such a system were far too high for the limited environmental benefit that it would bring. However, rainwater butts will be used to collect water from the roofs for plants in landscaped areas. This will help to promote a green, rural atmosphere whilst reducing storm runoff surges from the impermeable area of the roof.

Recycling

Domestic refuse disposal creates a major environmental impact. With the introduction of the European Union’s Sixth Action Framework Programme, it is proposed that landfill will be discontinued as a method of waste disposal. The practice of throwing away mixed domestic waste is a significant waste of energy and resources, as well as having impacts on the environment such as transportation, toxic landfill leachate and methane generation.

In addition, the construction process is responsible for the generation of considerable quantities of waste, much of which is also sent for landfill disposal.

During the construction process, segregated waste handling facilities will be available to allow recycling of wood, metals, synthetics and chemicals

Road Surfacing and Footpaths

As part of the development, the roads surrounding the site will require to be upgraded. Comely Green Crescent, which borders the site to the south and west, is currently surfaced with traditional stone sets which have a partial covering of tarmac. These sets will be removed during the upgrading of this section of road. We propose to recondition them and use them as paving within the development.

However, it is unlikely that sufficient sets will be available to completely pave the internal areas. Also, a section of the internal roadway is due to be adopted by the roads department. The specification of this road is therefore outwith the control of the design team, since the department will specify their requirements. For the remaining area of hardstanding, high recycled content materials will be used wherever possible.

Consideration is also being given to the use of porous materials or other ways of mitigating stormwater runoff from the site. Roof area runoff will be collected in rainwater butts and diverted to planted areas.

Planting

The design team has tried to maximise the amount of planting in the development to improve the atmosphere and feeling of the place, particularly within the enclosed courtyard. To increase as far as possible the feeling of naturalness, all species planted in the development will be carefully selected on the basis of the following criteria. They should:

- be native Scottish species
- as far as possible, be attractive all year round
- attract and support other species, such as insects, birds and mammals
- maintain a stable ecosystem.

Parking

The Comely Green Place development is a mixed ownership building. Some of the flats are scheduled for private sale, some will be shared ownership and some will be retained by the housing association. This mix of ownership, and particularly the prevalence of low-income families, means that the number of cars owned by residents is expected to be lower than normal.

However, the council transport department have guidelines for the recommended number of parking spaces that should be allowed for a development. These guidelines are intended to prevent unnecessary parking in the road.

For the purposes of the programme and for sustainable development in general, we would like to see these guidelines relaxed. The fewer car parking spaces that are required, the more room is available for planted amenity areas, which will increase the quality of the development and the quality of life for its occupants. We also wish to encourage the council, the residents and everyone else to use more sustainable forms of transport, such as buses and bicycles, which do not require such a large area of asphalt. At the time of writing, we are still negotiating this issue.

6.5 End of Life

The design life of the development is 100 years. We cannot pretend to know what the world will be like in a century's time but we do expect certain current trends to have continued. Principal among these is the concept of minimising the environmental impact of human activities. In the context of this development and the prevailing environmental and economic conditions, we have tried to achieve this goal.

When the building has reached the end of its useful life, we hope that this principle can be continued by re-using the materials that went into it. To this end we have given consideration to the issues of today which hamper the re-use of building materials. These can be summarised as:

- use of recalcitrant organic materials
- poor labelling
- mixing of different materials
- no quality control

We hope that the way in which the Comely Green Place development has been designed and built will make it easier to re-use its materials, so that it can go on reducing the environmental impact of housing long after the building itself has gone.